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# GENDER AND BODY SIDE DIFFERENCES OF GLENOID MORPHOMETRY

By

DR FADZILLAH BINTI MD. KHADZARI

DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF MEDICINE

(RADIOLOGY)

UNIVERSITI SAINS MALAYSIA

2015

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**UNIVERSITI SAINS MALAYSIA**

**2015**

## ***Dedication***

*To*

*My beloved husband,*

*For his prayers, endless love and encouragement*

*enables me to complete this study*

*and supported me throughout the master programme*

*My lovely sons and daughters,*

*For their prayers and cheers*

*My parents,*

*For their prayers and strong physical and emotional support*

## ACKNOWLEDGEMENTS

بسم الله الرحمن الرحيم

**In the name of Allah SWT, the Most Beneficent, the Most Merciful**

Alhamdulillah, the greatest gratitude to ALLAH the Almighty; for His help and permission to complete this dissertation within the allocated time frame.

I wish to convey my utmost appreciation to the following individuals who have imparted great assistant towards the completion of this study:

My supervisor, Dr Juhara Binti Haron, Lecturer of Radiology Department, Hospital Universiti Sains Malaysia, whose excellent guidance and encouragement enabled me to start from scratch.

My co-supervisor, Dr Tengku Muzaffar Bin Tengku Mohamed Shihabudin, Lecturer of Orthopaedic Department, Universiti Sains Malaysia for his facilitations throughout the study.

I also wish to express my gratitude to all my colleagues and the staffs from Department of Radiology Universiti Sains Malaysia, who assisted in every way for me to complete my dissertation.

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## ABREVIATIONS

| | |
|---|---|
| CT | Computed Tomography |
| MDCT | Multi Detector Computed Tomography |
| MPR | Multi Planar Reformatted |
| MR | Magnetic Resonance |
| 2D, 3D | Two Dimensional, Three Dimensional |
| PACS | Picture Archiving Communication System |
| HUSM | Hospital Universiti Sains Malaysia |
| ICC | Inter-class correlation |

# ABSTRAK

**Topik: Perbezaan Morfometri Glenoid Diantara Jantina Dan Bahagian Badan.**

**Latarbelakang**: Orientasi glenoid adalah penting bagi biomekanik sendi bahu. Data orientasi glenoid yang tepat adalah penting dalam menilai pelbagai permasalahan sendi bahu. Data ini juga berguna untuk perancangan sebelum pembedahan dan dapat mengurangkan peratusan kegagalan selepas pembedahan. Komplikasi yang di jangka mungkin berlaku temasuklah kelonggaran prostesis, ketidakstabilan bahu, keretakan prostesis, jangkitan, dan kecederaan saraf. Parameter yang penting berkenaan morphometric glenoid adalah panjang, lebar, sudut versi dan sudut kecenderungan.

**Tujuan Kajian**: Tujuan kajian ini adalah menggunakan mutiplanar imej CT untuk menentukan morfologi glenoid yang normal di kalangan pesakit yang menjalani CT thoraks di Hospital Universiti Sains Malaysia, serta membandingkan kiri, kanan dan perbezaan antara jantina.

**Kaedah dan Bahan**: Kajian ini merupakan satu kajian keratan rentas. Sebanyak 88 sampel CT thoraks telah dianalisis daripada tahun 2009 sehingga 2014 yang bukan kes otopedik di Jabatan Radiologi, Hospital Universiti Sains Malaysia (HUSM), Kubang Kerian, Kelantan.

**Keputusan**: Sejumlah 176 glenoid diukur. Purata panjang untuk glenoid dikalangan kaum lelaki ialah 4.03cm (SD 0.28) dan kaum perempuan 3.45cm (SD 0.27) . Purata

lebar untuk glenoid dikalangan kaum lelaki ialah 2.25cm (SD 0.23) dan kaum perempuan ialah 1.95cm (SD 0.23). Purata sudut versi di kalangan kaum lelaki ialah 4.25 (SD 4.20) dan kaum perempuan ialah 4.97 (SD 5.41). Purata sudut kecenderungan glenoid dikalangan kaum lelaki ialah 11.4 (SD 3.55) dan kaum perempuan ialah 8.77 (SD 4.26). Terdapat perbezaan yang signifikan dalam panjang dan sudut kecenderungan antara tulang belikat kiri dan kanan  Walau bagaimanapun, tiada perbezaan ketara diperhatikan dalam lebar glenoid dan sudut versi di kedua dua belah. Terdapat perbezaan yang signifikan dalam dimensi dan sudut kecenderungan antara lelaki dan perempuan. Walau bagaimanapun, tiada perbezaan yang ketara dilaporkan dalam sudut versi glenoid yang berlainan jantina.

**Kesimpulan**:  Dimensi glenoid yang di analisis dalam kajian ini adalah berbeza daripada kajian-kajian lain ke atas populasi berlainan. Terdapat perbezaan panjang dan sudut kecenderungan glenoid di antara tulang belikat kanan dan kiri. Dimensi dan sudut kecenderungan glenoid adalah lebih besar dikalangan kaum lelaki berbanding kaum perempuan.

## ABSTRACT

**Topic**: **Gender And Body Side Differences Of Glenoid Morphometry**

**Background:** Glenoid cavity orientation is crucial for the biomechanics of the glenohumeral joint. Reproducible data of the exact orientation and positioning of the glenoid cavity is important to evaluate various shoulder conditions. It is also useful as proper preoperative planning prior to replacement procedure and to minimize unfavourable implications of prosthetic failure. Among possible complications include prosthesis loosening, glenohumeral instability, tears of the rotator cuff, periprosthetic fracture, infection, neural injury, and dysfunction of the deltoid. The important parameters of glenoid morphometry are glenoid length, width, glenoid version and glenoid inclination.

**Aim of study**: The aims of this study were to use multiplanar reconstructed CT images as the modality to determine the normal glenoid morphology among patients who underwent CT thorax in Hospital Universiti Sains Malaysia, to compare side and gender differences.

**Methods and Materials**: This study was a cross sectional study. A total of 88 CT thorax were analyzed from 2009 to 2014 for non orthopaedic indications in Department of Radiology, Hospital Universiti Sains Malaysia (HUSM), Kubang Kerian, Kelantan.

**Results**: A total of 176 glenoid cavities were measured. The mean glenoid length in male were 4.03cm (SD 0.28) and in female 3.45cm (SD 0.27). The mean for the glenoid width in male were 2.25cm (SD 0.23) and in female 1.95cm (SD 0.23).. The average glenoid version angle in male was 4.25 (SD 4.20) and in female was 4.97 (SD 5.41). The average glenoid inclination in male was 11.4 (SD 3.55) and in female was 8.77 (SD 4.26). There was significant difference in glenoid length and glenoid inclination between right and left scapula. However no significant difference observed in glenoid width and glenoid version between two sides. Significant difference also noted in mean value of glenoid dimension and glenoid inclination between male and female. However no significant difference reported in glenoid version of different gender.

**Conclusion**: The dimensions of the glenoid observed in the present study were different from other studies done on other populations. The difference was found in glenoid length and inclination between right and left scapula. The glenoid dimension and inclination are significantly larger in male than female.

# SECTION 1

# INTRODUCTION

# SECTION 1

# INTRODUCTION

Medical advancement in the modern era can be divided into two separate but connected approaches, both aimed to make us lives better. In the early 90s it was a ‘war against diseases’ hence prolonging one’s life, but in the years to come it was to give more quality to life itself through medicines and advance medical intervention. This is especially true when talking about intact locomotor system because humans are mobile in nature. In this regard, orthopaedic surgery especially arthroplasty is the most significant field compared to others. Its startlingly rapid progress in developing new effective methods of treatments eclipse other fields of orthopaedic surgery (Morscher, 2003).

Shoulder replacement procedures, recently has increased substantially in number, parallel to the total number of total joint arthroplasties. From year 1996 to 2002, about 7000 surgery performed in United States each year, in which 40% increased in annual number of athroplasties (Bohsali *et al.*, 2006). The first shoulder replacement surgery was performed in 1893 by Pean, a French surgeon using platinum and rubber prosthesis. It is used for treatment of tuberculous arthritis of the shoulder. This was years prior to endoprosthetic replacement of the hip (Wirth and Rockwood Jr, 1996) Subsequently, in early 1950s, Neer started his first humeral head replacements for fracture and fracture dislocation of shoulder joint. Total shoulder athroplasty was then introduced in 1970 (Brems, 1993).

In practice, the most frequent dislocated joint cases are the shoulder joint. Commonly, it is associated with fractures of the glenoid. To treat this, apart from labrum and capsule repair, some cases may need total shoulder replacement (Mamatha *et al.*, 2011). For many painful shoulder condition, total shoulder arthroplasty has become second line of therapy, after failure in conservative therapies (Deshmukh et al., 2005). These painful shoulder conditions includes osteoarthritis, rheumatoid arthritis, juvenile rheumatoid arthritis and avascular necrosis of the joint (Hawkins et al, 1989).

Shoulder arthroplasty is associated with variable rate of numerous complications, including prosthetic loosening, glenohumeral instability, tears of the rotator cuff, periprosthetic fracture, infection, neural injury, and dysfunction of the deltoid. Symptomatic loosening of the glenoid and the humeral component after a total shoulder athroplasty is common and accounting nearly one-third of all complications associated with this surgery. Majority of loosening cases are due to fixation failure of glenoid component. Mean complications rate associated with total shoulder arthroplasty ranging 10% to 16% (Bohsali et al., 2006).

Therefore, proper preoperative planning prior to replacement procedure is crucial to minimize unfavourable implications of prosthetic failure. Traditionally, majority of cases, plain radiographs used as qualitative assessment of glenoid cavity. Unfortunately, it only provides 2D analysis of scapula, which is not accurate enough to give precise information of the glenoid and its pathological changes. In recent years, with new technologic advances, three dimensional CT images were established, allowing accurate visualization of the scapula (Kwon *et al.*, 2005). Multi-planar reconstructed CT image is a good alternative method for accurate assessment of glenoid cavity. It allows visualization and qualitative analysis of the glenoid in three planes simultaneously. With this method, a more accurate baseline data of glenoid morphology is obtainable.

# SECTION 2

# RATIONALE OF STUDY

## SECTION 2

## RATIONALE OF STUDY

Great efforts have been taken by many countries in establishing their own anthropometric database for variety of population. In relation to this, ethnic variations have significant effect on the anthropometric data and the scope of its applications. Even among different ethnics of East Asia i.e Taiwanese, Korean, Japanese and Chinese, it was reported that most of mean dimensions and body proportion have significant differences. The morphological characteristics are also not the same (Lin et al., 2004).

Until now, not many studies have been performed regarding morphology characteristic of glenoid cavity of shoulder joint in our population. Previous study on morphological aspect of glenoid cavity mainly performed on Caucasions populations (Churchill et al., 2001). Mamatha et al, 2011 reported that, dimensions of glenoid cavity amongst the South Indies are smaller than in other populations. Due to this fact, it is an utmost important to produce our own populations' glenoid cavity dimensions database to design a suitable glenoid component in arthroplasty.

In total shoulder arthroplasty, loosening of prosthesis component is a common complication. Majority of cases are due to failure fixation of glenoid component (Bohsali et al., 2006). By studying the morphology of glenoid cavity in our population, perhaps a precise database can be assembled. More precise and compatible prosthesis can be produced with less complication.

The morphology and pathological changes of glenoid cavity is less accurate on plain radiographs images. In order to improve the analysis, three dimensional imaging is introduced. Utilisation of three dimensional or multiplanar-computed tomography of the shoulder can increase accuracy of glenoid cavity assessment. It provides data for preoperative planning and generate more compatible and fit implant for shoulder arthroplasty. Three dimensional imaging also has potential in detecting variation in configuration (Scalise *et al.*, 2008).

# SECTION 3

# LITERATURE REVIEW

# SECTION 3

# LITERATURE REVIEW

## 3.1 Normal Shoulder Joint And Its Functions

The normal functioning of shoulder joint depends on a balance between the muscle, ligament and capsular structures (Figure 3.1 and Figure 3.2). It requires an interaction between static and dynamic components. In the shoulder complex, it has series of joints, muscles, ligaments, bursae and capsules. The series of joints are referring to glenohumeral joint, acromioclavicular joint and sternoclavicular joint. Another factor that play a role in shoulder joint stability and range of movement is the shape of articulating surfaces and capsuloligamentous structures (Hess, 2000). These anatomical structures are interdependent to each other and determine the normal movement of shoulder complex.

The dynamic action of shoulder complex mainly contributed by glenohumeral joint and rotator cuff muscles (Prescher, 2000). The glenohumeral joint has the highest degree of freedom in the joints of the human body. This range of motion is caused by the disproportion in the areas of the humeral head and the glenoid cavity. The surface area of glenoid cavity is one third to one fourth that of the humeral head. Glenohumeral joint is a ball and socket type of synovial joint. Basic function of shoulder complex is to support the upper limb in both static and dynamic. It also play a major role in range of movement and positional control of the upper limb (Peat, 1986).

The shoulder joint is surrounded by capsule and attached medially to the margin of glenoid beyond the labrum. Laterally, it is attached to the anatomical neck of humerus. It is a thin structure which does not contribute much in joint stability. The capsule structure is mainly maintained by surrounding ligaments and tendon of rotator cuff muscles. The weakest part of the capsule is the inferior part. It is lined by a synovial membrane. At the inferior aspect of the articular capsule, has a reverse fold, forming the 1 cm deep axillary recess. It is important in joint's function in which it acts as a reserve fold and as a complementary space for the humeral head during abduction.

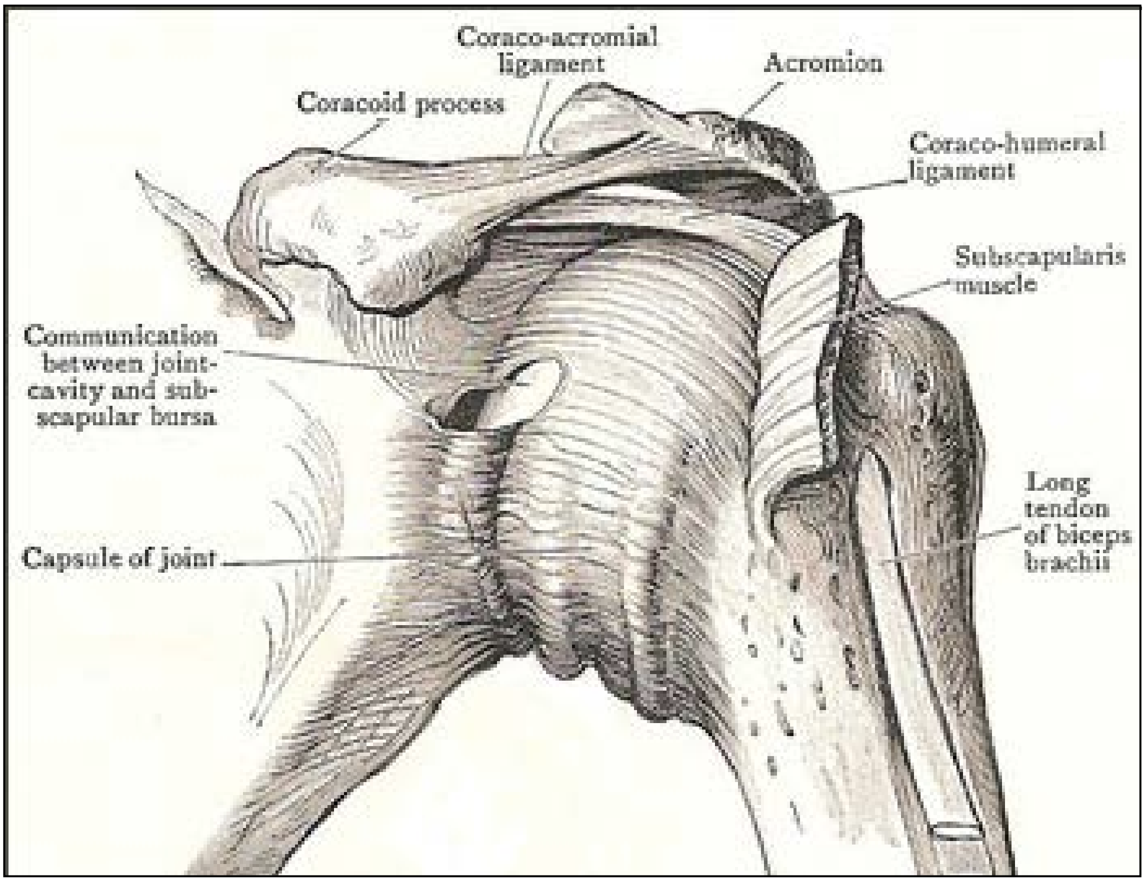


Figure 3.1 Normal shoulder joint anatomy

Source: **http://www.daviddarling.info/encyclopedia/S/shoulder.html**

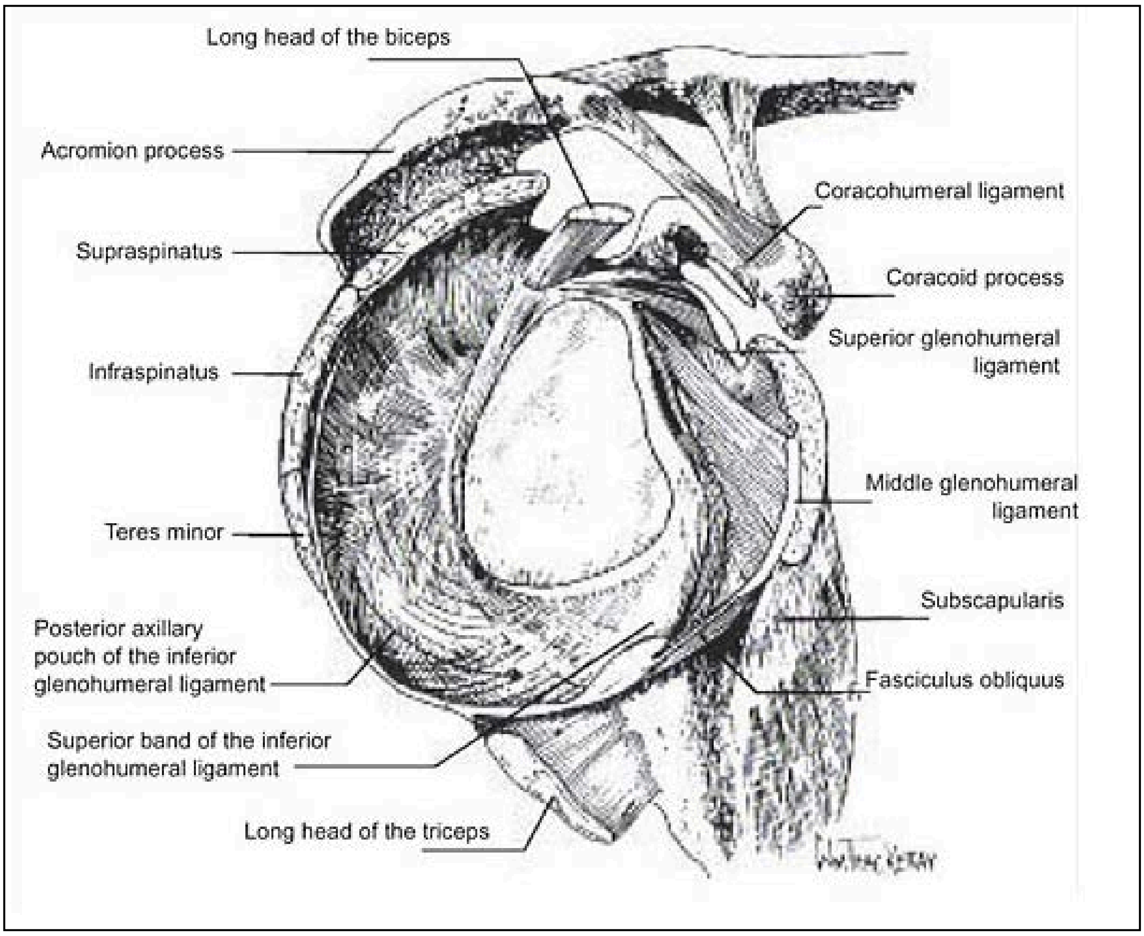


Figure 3.2 Cross section of the shoulder joint.

Source: http://www.hkma.org/english/cme/onlinecme/cme200611main.htm

## 3.2 Normal Glenoid Cavity

Glenoid cavity is at the lateral part of scapula, which is slightly concave and pear shape (Figure 3.3). The surface are ranging from 6-8cm$^2$, which is about one third to one fourth of humeral head. The longer axis is the length which is oriented in superior-inferior direction. The average length is 3.5cm to 4cm. The width, which is in tranverse axis, averages 2.5cm to 3cm. The glenoid is slightly tilts upward (5°) in relation to the medial scapula border (Brems, 1993). It is slightly retroverted ranging from 4 to 8 degree (Prescher, 2000).

The glenoid tubercle is inferior to the center of glenoid cavity which seen as slight elevation of the floor. At this tubercle, the articular cartilage thins out and often changes to fibrous cartilage. Superior to the glenoid cavity, located intraarticularly, is a supraglenoid tubercle. This is the origin of the tendon of long head of bicep muscle. Inferior to the glenoid cavity, at the extraarticular region, is the infraglenoid tubercle, which is the origin of long head of tricep muscle. This tubercle is seen as an irregular tuberosity (Peat, 1986).

Surrounding the margin of the glenoid cavity is a rim of fibrocartilaginous tissue also known as glenoid labrum. Synovium covered the inner surface of labrum. The outer suface of labrum is attached to the capsule and is continuous with the scapular neck. The major function of glenoid labrum is for ligament attachment.

There are few bony landmarks consistently detectable on AP radiograph and CTscan of the shoulder. It includes articular surface of glenoid fossa, the scapular spine, and the floor of supraspinatus fossa and lateral margin of the scapula. In context of arthroplasty, an intimate knowledge of the shapes and dimensions of the glenoid cavity are important in considering the design and fitting of glenoid components.

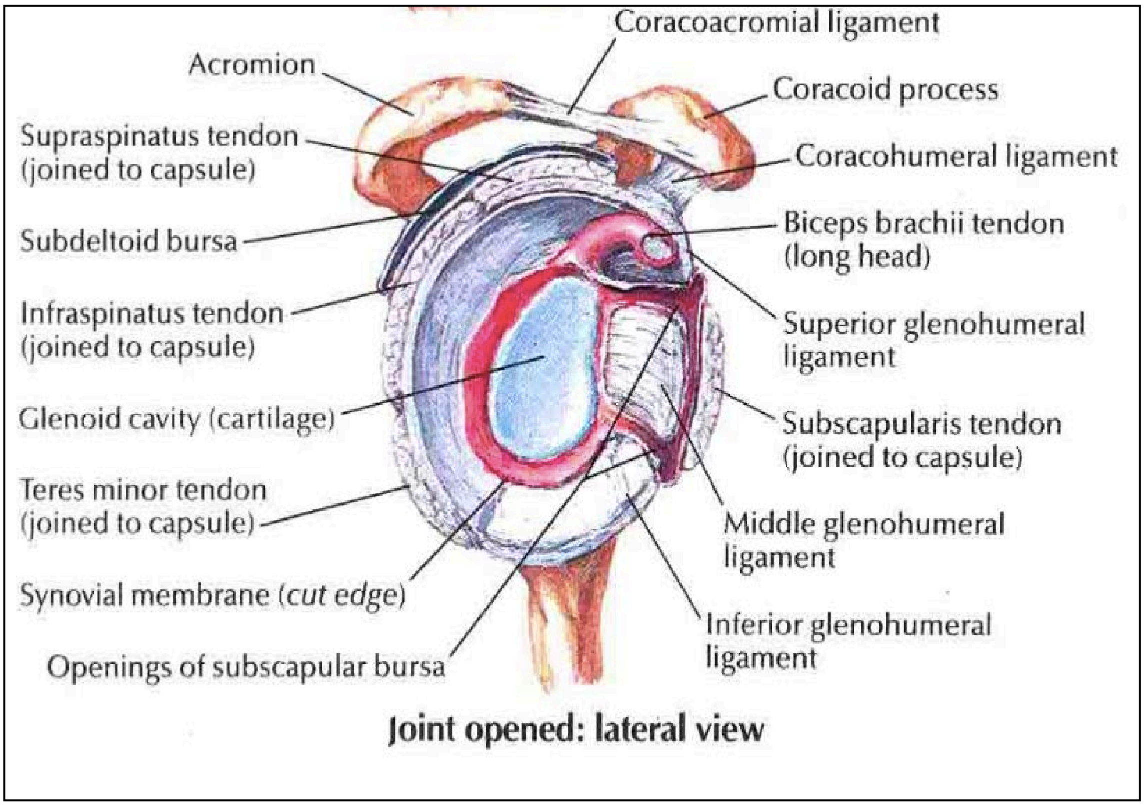


Figure 3.3 Normal glenoid cavity anatomy

Source: Netter image

## 3.3 Normal variant of glenoid cavity

Most literature described the shape of the glenoid cavity as pear-shaped, round, oval or having an inverted comma-shape (Figure 3.4). All these descriptions depending on the presence or absence of a distinct glenoid notch (Prescher and Klumpen, 1997). According to Prescher et al, 2000 the glenoid notch is located at the anterior margin of the glenoid cavity. It is situated above the middle of the anterior margin of the cavity and can be very prominent, very shallow or absent. It is also known as 'incisura acetabuli'. In 55% of population, the glenoid notch is well visualized and a pear shaped glenoid cavity results. In 45%, the notch is absent and an oval cavity can be seen °°°(Prescher, 2000).

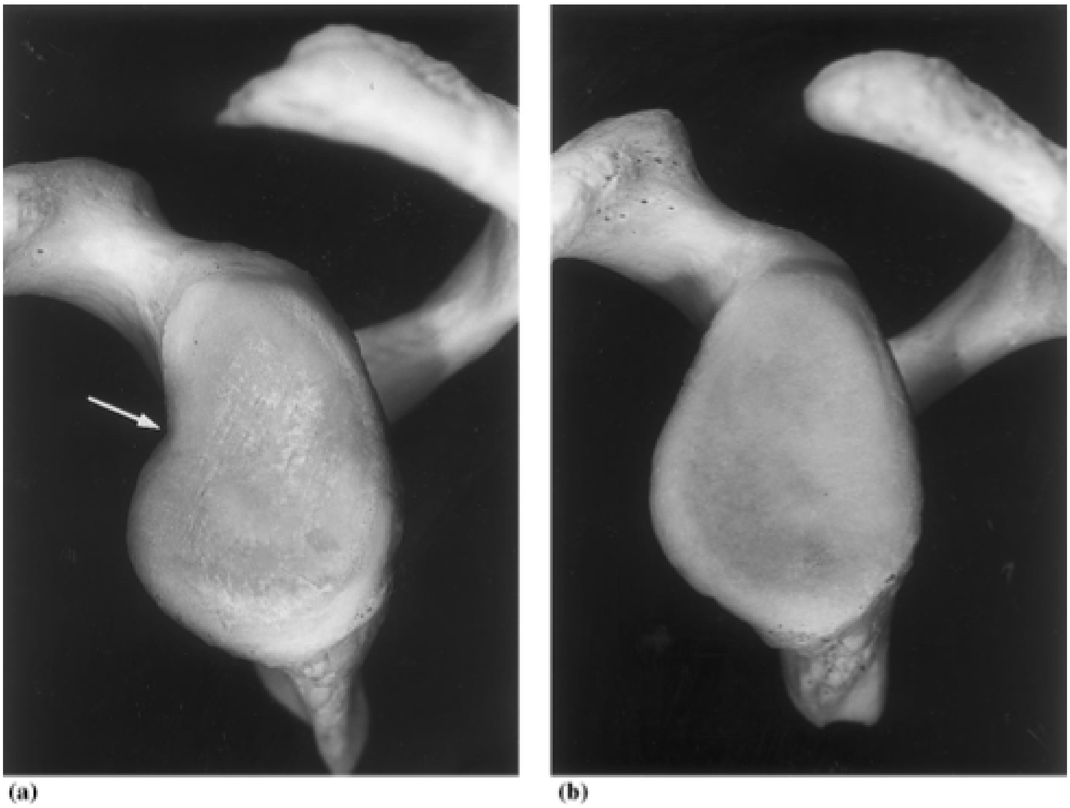

Figure 3.4 Normal variant of glenoid cavity

(a) Left glenoid cavity with a pronounced glenoid notch (arrow).

(b) Left glenoid cavity without glenoid notch

Source: (Prescher, 2000)

### 3.4 Glenoid Size and Orientation

The orientation of glenoid cavity is important for biomechanics of the glenohumeral joint. In evaluating various shoulder conditions, baseline and reproducible data of the precise size and orientation of the glenoid cavity must be acquired. Orientation and size can be assessed either anatomically, radiographically or intraoperatively. Orientation of glenoid cavity is described by its version and inclination. These orientations should be measured by consistently identifiable bony landmarks.

### *3.4.1 Glenoid size*

In Cleveland population, Kwon et al, 2005 performed a study on CT scan of 12 normal cadaveric scapula. The scapula were placed in a supine anatomic position. Axial images were obtained in 1 mm slice thickness along the axial axis of human body and three dimensional CT images were processed. Data obtained from direct measurement of the scapula and 3D CT images. The morphometric measurements obtained in this study includes the glenoid dimensions which are glenoid width and length. The greatest dimension between any two points on the rim is representing the maximum glenoid length. The greatest dimension which is perpendicular to the glenoid length is assigned as the maximum glenoid width. The mean of glenoid length and width from direct measurements of the scapula were 3.78cm (SD 0.5) and 2.68cm (SD 0.5) respectively. Measurements from 3DCT were similar, 3.91cm (SD 0.6) and 2.52cm (SD 0.5) respectively. No comparison made in different gender or right and left scapula.

Another study compared the glenoid size between races and gender in Ohio population. This study used direct measurement method onto the paired scapula specimen. The glenoid dimensions were not found to vary between the 2 races studied. However, there was significant difference statistically between male and female samples. The male glenoid width and height were 2.78cm (SD 0.2) and 3.75cm (SD 0.2) respectively. The female glenoid width and height were 2.36cm (SD 0.1) and 3.26cm (SD 0.2cm) respectively.

An original research performed by Andrea Merrill, 2008, on gender differences in glenoid anatomy. This author measured directly the 184 pairs scapular bone using digital calipers. There was significant difference between male and female specimens in glenoid size, notch location and depth. Glenoid size was larger in male. These differences between male and female glenoid anatomy are important in shoulder surgeries.

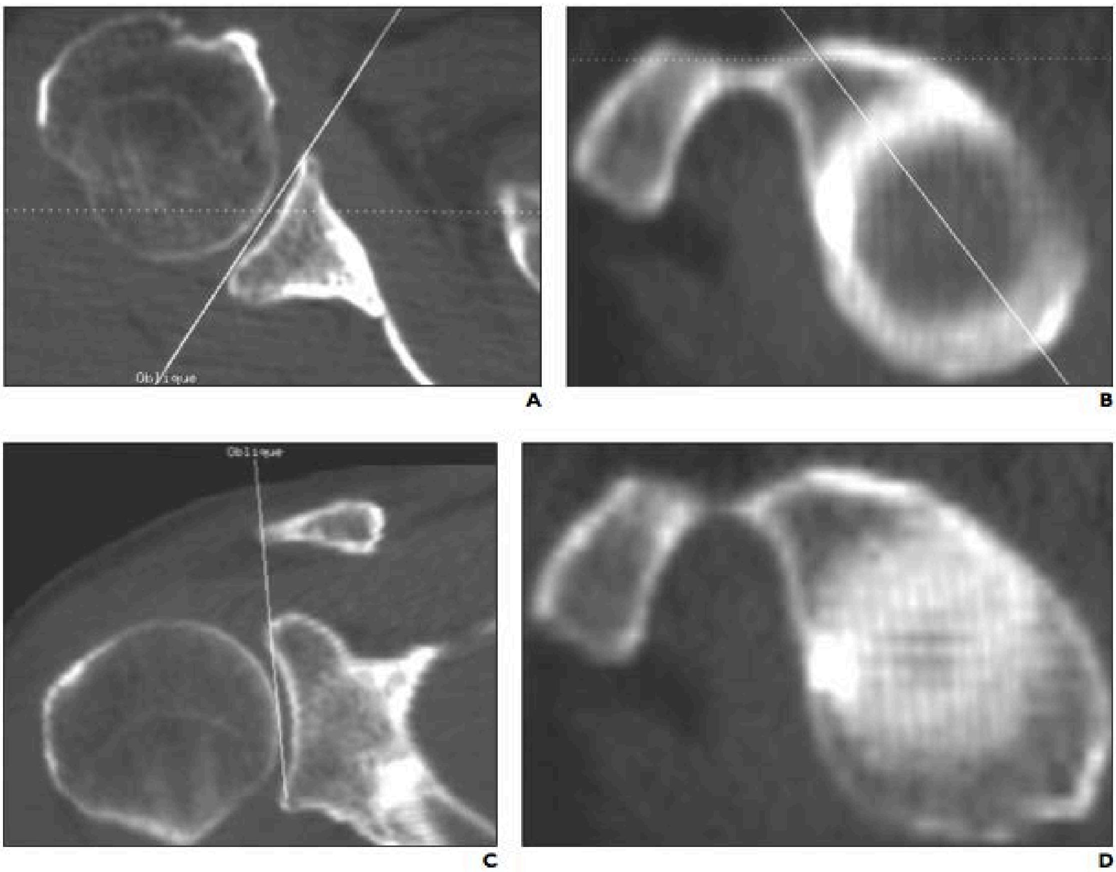


Figure 3.5 En face image of glenoid fossa

Images obtained through successive reconstruction in the oblique, coronal and saggital planes (double oblique reformations of CT image). Source: (Griffith *et al.*, 2003)

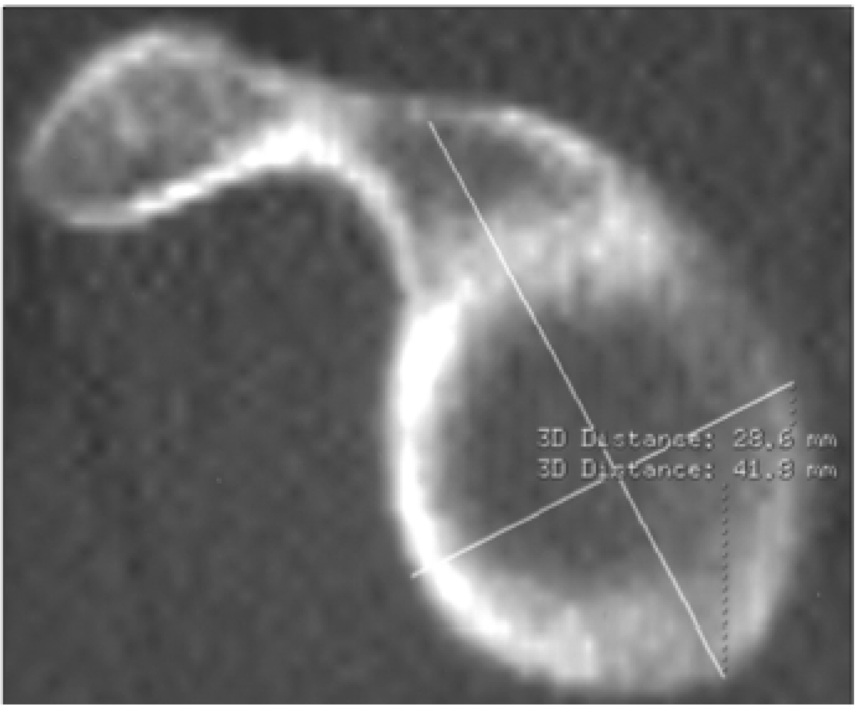


Figure 3.6 Glenoid width and length

Maximum glenoid length measured by drawing line at right angle to original line across width of glenoid fossa.

Source: (Griffith *et al.*, 2003).

### *3.4.2 Glenoid version*

The angulation of glenoid fossa is of varying degrees. Based on study performed by *Churchill et al, 2001, g*lenoid version measured based on two different methods. The researcher is using a direct measurement onto 172 pairs of scapular bones from persons who aged 20 to 30 years old. This study was performed by direct measurement with an electronic caliper. First, the measurement made in relation to the tranverse axis of scapula. Tranverse axis of scapula is defined as the line from the centre of glenoid cavity to the junction of the scapula spine and the medial border of the scapula. Another method is by measuring perpendicular to the glenoid inclination in perpendicular plane. (Churchill *et al.*, 2001).

This study stated that no significant difference statistically between this two method. The glenoid version measured perpendicular to glenoid inclination was slightly greater than the mean version, when measured with respect to the tranverse axis of scapula. The overall glenoid version for the entire group was 1.23° retroversion. The difference in glenoid version between black and white patients was statistically significant. The mean glenoid version for black and white male was 0.11° and 2.87° retroversion respectively. The mean glenoid version for black and white female was 0.3° and 2.16° retroversion respectively. When compared between different sex, no statistically significant difference detected (Churchill *et al.*, 2001).

Another similar study performed by Charleston et al, 1992 on CT scan of glenohumeral joint belong to normal subjects and osteoarthritis or inflammatory arthritis patient. In this study, the researcher using only one method to measure the glenoid version. They are using the similar tranverse axis, a line drawn from midpoint of the glenoid fossa to the medial end of the scapula. Another line is between the anterior and posterior margin of glenoid. A neutral version is considered, if a line drawn perpendicular to the tranverse axis. If the posterior margin of glenoid is medial to the 'neutral version line', it is defined as retroversion. As for anteversion, is when the anterior margin was medial to the 'neutral version line'. The version angle is between the neutral version line and the line connecting the anterior and posterior margin of glenoid (Figure 3.4). In this study they conclude that CT is the ideal method in determining the glenoid version in axial plane of scapula (Carolina,1992).

This study CT scan is performed in axial plane with 2.5mm contiguous slices. In 63 healthy patients, the glenoid version in male is 2° anteversion and in female is 3° anteversion. No significant difference in gender and right and left shoulder. However, there was significant difference of of glenoid version between healthy and arthritis group (RJ Friedman,1992).

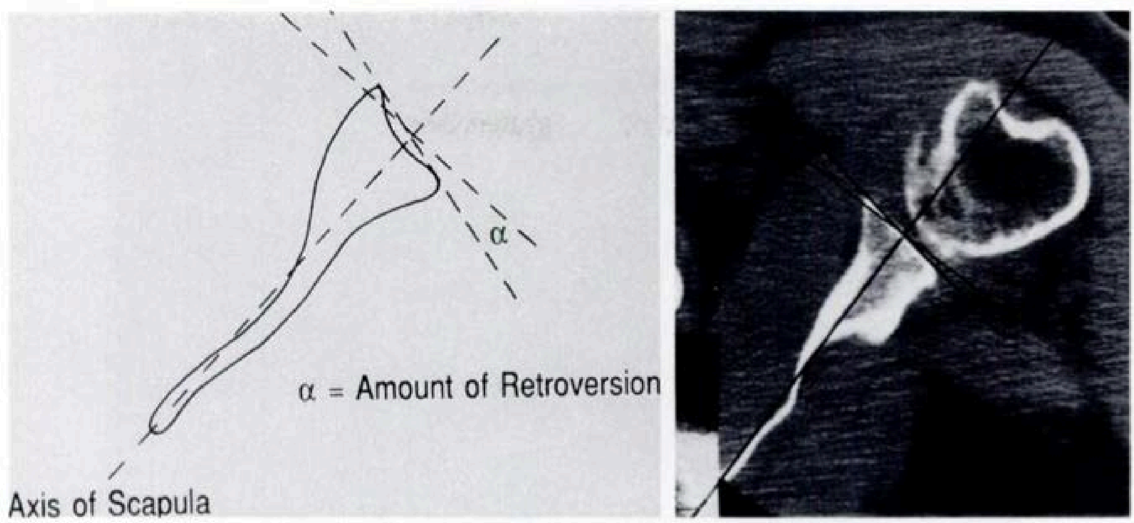


Figure 3.7 Measurement of glenoid version angle

Source: (Carolina,1992)

Richard Nyffeler, 2003 analyzed the measurement of glenoid version in conventional radiographs on axillary views versus computed tomography (CT) scans at the mid glenoid level. The mean glenoid version measured on CT scans was 3° of retroversion in the instability group (range, 7° of anteversion to 16° of retroversion) and 2° of anteversion in the total shoulder prosthesis group (range, 16° of anteversion to 23° of retroversion). On axillary radiographs, the value were 9° retroversion in instability group (range 5° anteversio to 21° retroversion) and 5° retroversion (range 13°

anteversion to 26° of retroversion) in prothesis group. Glenoid retroversion was overestimated on plain radiographs in 86% (Nyffeler *et al.*, 2003).

Axillary radiographs of the shoulder joint were obtained with the patient in the supine position on the table, with the arm in neutral rotation and in 60° of abduction in the scapular plane. The measurement technique consisted of drawing a line along the maximum anteroposterior length of the pear-shaped glenoid cavity and another line drawn from the midpoint of the above length through the middle of the scapular blade, approximating the scapular axis as closely as possible (Figure 3.8). Glenoid version was defined as the angle between the first line and a line perpendicular to the second line.

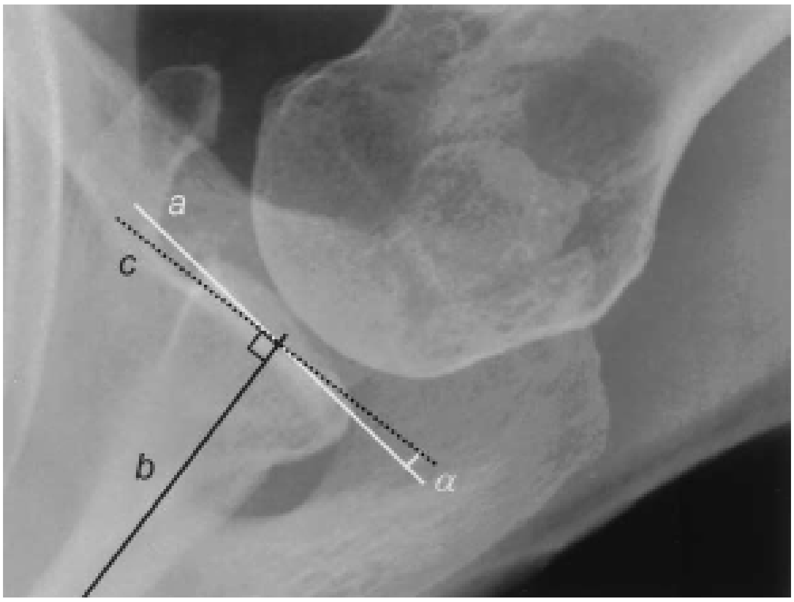


Figure 3.8 Axillary view of a right shoulder showing the technique used for measurement of glenoid version: *a* represents the glenoid plane, *b* represents the plane of the scapular blade, and *c* represents the plane perpendicular to the scapula. The angle α represents the retroversion of the glenoid cavity. Source (Nyffeler *et al.*, 2003)

CT 4mm slices scans were obtained with patients in the supine position with the shoulder flat on the examining table and the humerus at the side. As measurement of glenoid version depends on the rotation of the scapula in the coronal plane, only CT scans in which the glenoid surface was perpendicular to the plane of the CT slices were included. Glenoid version was determined with the method described by Carolina *et al*, 1992.

This study conclude few factors that causing overestimate of the glenoid version on plain radiograph:

- Superimposed of the superior and inferior glenoid margin
- Unable to view medial border of scapula
- Variation in alignment of x raybeam results in changes of glenoid version value.

### *3.4.3 Glenoid Inclination*

In a study by Maurer et al, 2012 on conventional anterior-posterior (AP) radiographs and CT scan of the shoulder, they are using three methods in assessing the glenoid inclination (Figure 3.9). The glenoid fossa line is taken as a reference line for all of these method. The glenoid fossa line is defined in coronal oblique view through the center of glenoid connecting the uppermost and lowermost point of glenoid (line AB). The first method is the angle of glenoid inclination between the spine of scapula and glenoid fossa line (α°). The upper cortical margin of the spine medial to the glenoid is used. The lateral aspect of the spine is usually curved. Second method is the angle between the floor of supraspinatus fossa and glenoid fossa line (β°). On radiographs, the floor of supraspinatus fossa seen as sclerotic line, whereby on CT images, it is along the cortical margin of deepest point of the supraspinatus fossa.  The third method, is the angle between glenoid fossa line and lateral margin of the scapula (γ°). The lateral margin of the scapula is the cortical border which is medial to the neck of the glenoid. On CT image, it is best assessed in coronal view (Figure 3.10).  This study conclude that the angle of inclination from second method is more reliable. It is resistance to different scapular positioning with easily identifiable reference line (the floor of supraspinatus fossa). The inter-rater reliability of this angle between plain radiograph and CT scan is also good (Maurer *et al.*, 2012).  From this study, variable value of glenoid inclination obtained from different method and imaging.

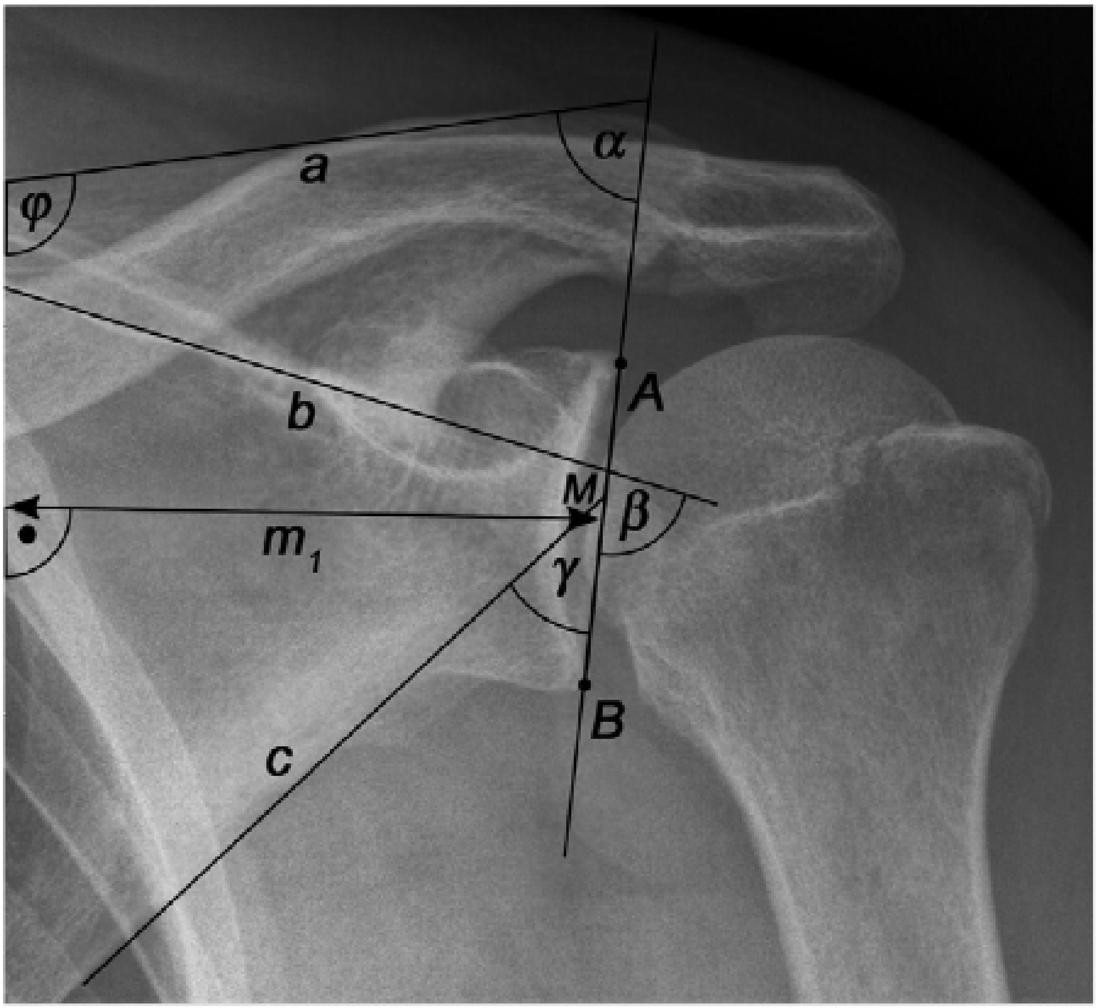


Figure 3.9 Definition of glenoid inclination angles on plain radiograph of shoulder.

*AB* line - glenoid fossa line connecting the uppermost point (A) and the lower most point (B) of the glenoid.

$\alpha°$ - is the angle between the spine of scapula (a) and glenoid fossa line (AB)

$\beta°$ - is the angle between floor of the supraspinatus fossa (b) and the glenoid fossa line (AB)

$\gamma°$ - is the angle between lateral margin of the scapula and the glenoid fossa line (AB)

Source: (Maurer *et al.*, 2012)

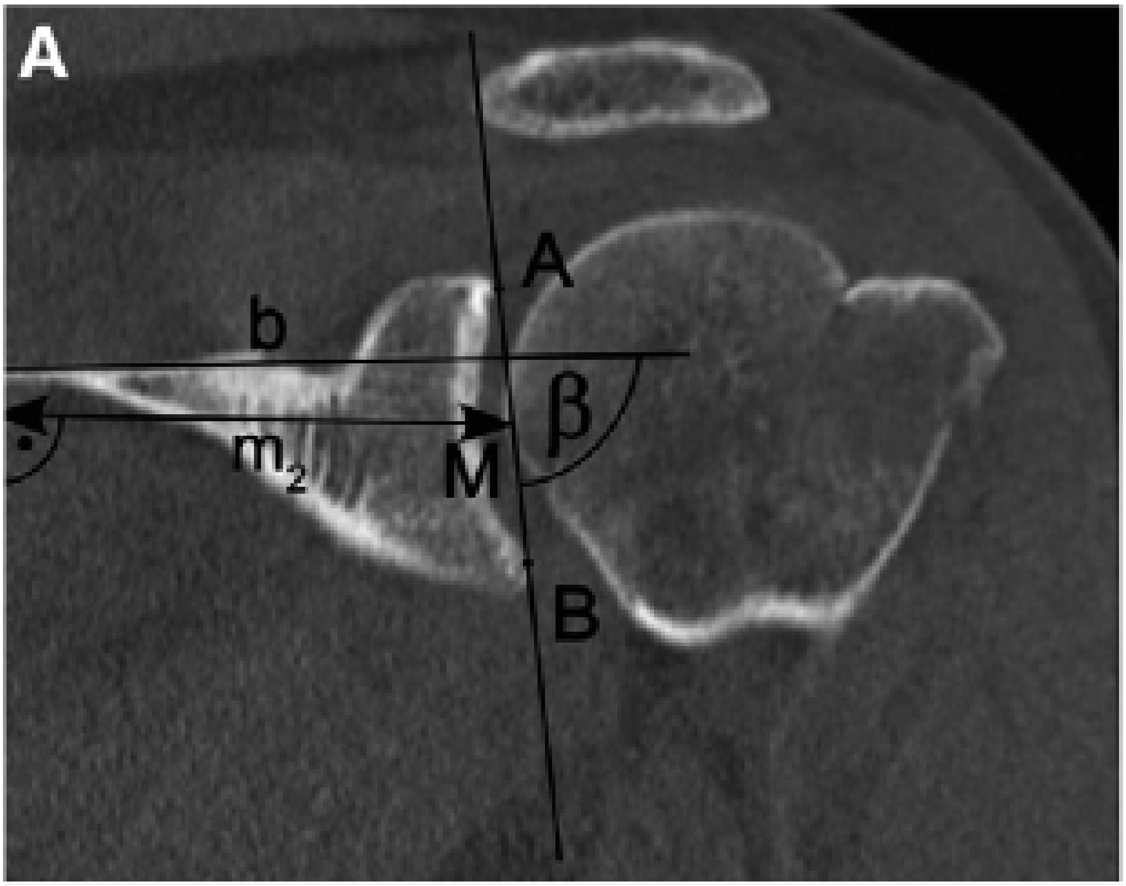


Figure 3.10 Definition of glenoid inclination angles on CT scans

*Glenoid fossa line (AB)* – in coronal oblique image through the center of the glenoid connecting the (A) uppermost point and (B) lowermost point of the glenoid.

*β°* – is the angle between the floor of supraspinatus fossa (b) and the glenoid fossa line (AB).

*Line b* – line along the cortical margin of the floor of the supraspinatus fossa.

Source : (Maurer *et al.*, 2012)

Churchill et al. 2001 reported by direct measurement of 172 pairs scapular bone using electronic caliper, based on tranverse axis of scapula. On average, combined female group had greater inclination than combined male group with mean value 4.5 (SD 3.8) and 4.0 (SD 3.4) respectively. In view of different races, white group had greater inclination than black group with mean value 4.6 (SD 3.6) and 3.9 (SD 3.6)